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LIGHT INJECTION TRANSMITTER  
[Kouchuunyuu souchin souchi]

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## 1. Title of the Invention

Light Injection Transmitter

## 2. Claims

(1) A light injection transmitter comprising a 1<sup>st</sup> semiconductor laser, a 2<sup>nd</sup> semiconductor laser receiving the output light of the 1<sup>st</sup> semiconductor laser, and an electrical signal input terminal for imparting an excitation signal to the 1<sup>st</sup> and 2<sup>nd</sup> semiconductor laser, with synchronization of the injection light signal injected to the 2<sup>nd</sup> semiconductor laser and the excitation signal of the 2<sup>nd</sup> semiconductor laser.

(2) A light injection transmitter according to Claim (1) wherein the excitation signal of the 2<sup>nd</sup> semiconductor laser has a time delay of 10PS- several 100PS with respect to the injected light signal injected to the 2<sup>nd</sup> semiconductor laser.

(3) A light injection transmitter according to Claim (1) or Claim (2) wherein the oscillatory light spectrum of the 1<sup>st</sup> semiconductor laser is a single spectrum.

(4) A light injection transmitter according to Claim (3) wherein the oscillating light spectrum of the 2<sup>nd</sup> semiconductor laser becomes a single spectrum by the injection light signal, matching the single spectrum of the injection light signal.

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\*Numbers in the margin indicate pagination in the foreign text.

### 3. Detailed Description of the Invention

This invention, in addition to semiconductor laser which function especially as transmitting light sources, is related to a light injection transmitter outputting light which is light injected to this semiconductor laser.

Light transmitters using light fiber transmission devices and the like use semiconductor lasers as light sources, and by directly driving this semiconductor laser by a modulated signal current generally execute oscillation and modulation simultaneously. In this case, in order to obtain the output light at a high level, many drivers of the semiconductor laser exist using modulated signals of large amplitude, and in doing so, the oscillation spectrum width of the semiconductor laser becomes wide, and as a general rule, become multi vertical mode. When the light spectrum of the transmitted light becomes wide, by material dispersion of the light fibers used in /292 the transmission path, mode distributed noise is generated at the transmission path output terminal, resulting in a defect which degrades the cyclic nature of the signal light. In addition, when performing heterodyne wave detection at the receiving side, a defect occurs because of degradation of the receiving sensitivity when the transmitted light has not a single spectrum.

According to the structure of the semiconductor laser, normally, when direct current is the excitation source, the semiconductor laser oscillates with a single spectrum. Because of this single spectrum,

conventionally, by injecting the output light of the semiconductor laser excited by a single spectrum by direct current excitation to a semiconductor laser oscillating in multi vertical mode through excitation using modulated signal current, technology was developed for making light spectrum of output light from light injected semiconductor lasers into single spectrum oscillation by matching with the single spectrum of injected light.

However, with this conventional technology, when the semiconductor receiving light injection is not modulated by a pulse signal, because light is injected at time encoded "0" does not generate laser oscillations in this semiconductor laser, an increase in noise is generated at time encoded "0."

The goal of this invention is to provide a light injection transmitter which controls the noise of an injection semiconductor laser by the injected light.

According to this invention, the invention is a light injection transmitter comprising a 1<sup>st</sup> semiconductor laser, a 2<sup>nd</sup> semiconductor laser receiving the output light of the 1<sup>st</sup> semiconductor laser, and an electrical signal input terminal for imparting an excitation signal to the 1<sup>st</sup> and 2<sup>nd</sup> semiconductor laser, with synchronization of the injection light signal injected to the 2<sup>nd</sup> semiconductor laser and the excitation signal of the 2<sup>nd</sup> semiconductor laser.

With the light injection transmitter of this invention, the 1<sup>st</sup> semiconductor laser outputting the injected light is modulated by an

information signal equal to the signal exciting the 2<sup>nd</sup> semiconductor laser to which light was injected, and furthermore, when the injected light signal which is the output signal of the 1<sup>st</sup> semiconductor laser is injected to the 2<sup>nd</sup> semiconductor laser, synchronization occurs with an excitation signal of this 2<sup>nd</sup> semiconductor laser. Because of this synchronization, when, for example, the signal inputting to the electrical signal input terminal is a pulse encoded modulated signal, encoding of the excitation signal of the 2<sup>nd</sup> semiconductor laser matches the encoding of the injected light signal.

However, if the direct current pulse current and a small amplitude pulse signal current are used, slightly larger than the threshold current, from the 1<sup>st</sup> semiconductor laser, when encoding of the output light is "1", a light signal pulse modulated from single spectrum oscillation can be output. On the other hand, if a direct current bias current slightly smaller than the threshold current and a large pulse signal current is used for the excitation signal current of the 2<sup>nd</sup> semiconductor laser, when no light is injected, the oscillation spectrum is not single and it is possible to output a light signal that has been high output pulse modulated by the 2<sup>nd</sup> semiconductor laser.

Here, if the injected light signal which is the output light signal of the 1<sup>st</sup> semiconductor laser is injected to the 2<sup>nd</sup> semiconductor laser, when encoding of the excitation signal of the 2<sup>nd</sup> semiconductor laser is "1", the level of the light injected signal

using encoding the of the injected light signal as "1", is comparatively high, and furthermore, because the light spectrum of the injected light signal is single, along with the oscillation light spectrum of the 2<sup>nd</sup> semiconductor laser becoming a single spectrum matching the single spectrum of the injected light, the light pulse of a high peak value and encoding "1" can be output by the 2<sup>nd</sup> semiconductor laser.

On the other hand, when the encoding of the excitation signal of the 2<sup>nd</sup> semiconductor laser is "0", because the level at encoding of the light injection signal "0" is low, the effect on the operation of the 2<sup>nd</sup> semiconductor laser is slight, with hardly any noise generated by the injected light, and in addition, the noise is unusually small when compared to an encoding of "1" at a light level output from the 2<sup>nd</sup> semiconductor laser.

Next, an explanation is given of embodiments of this invention by referencing the drawings.

Fig. 1 is a block diagram showing the structure of one embodiment of this invention and Fig. 2 is a diagram showing one part of the signal waveform for each part in order to explain this embodiment.

The modulated signal input to the electrical signal input terminal 1 is introduced to the branching circuit 2 and is divided into 2 equal signals. After one of the signals of output from this branching circuit 2 is conducted to the 1<sup>st</sup> driving circuit 3 and

/293

amplified, the signal is applied to the 1<sup>st</sup> semiconductor laser 4 by superimposing on the direct current bias current. The threshold current for this semiconductor laser 4 is 30mA at a temperature of 25°C, and the laser 4 is an InGaAsP laser of oscillating wavelength approximately 1.56μm, having an embedded hetero structure. The modulated signal input into the electrical signal input terminal is a signal pulse encoded modulated signal with a duty factor of approximately 50%, and the waveform of this signal is shown in Fig. 2(v) and the encoding in Fig. 2(a).

Along with the signal being modulated to a signal having a pulse peak at 10mA using the 1<sup>st</sup> driving circuit 3, the signal is superimposed on the circuit current bias current of slightly higher value (35mA) than the threshold current of the 1<sup>st</sup> semiconductor laser 4. From the 1<sup>st</sup> semiconductor laser 4, the light power is 1.5mW when the pulse encoding is "1", the light spectrum is a single spectrum, and the light pulse signal is output with a light power of 0.5mW when the pulse encoding is "0." The waveform of this light pulse signal is shown in Fig. 2(c) corresponding to Fig. 2(b).

The light pulse signal from the output of the 1<sup>st</sup> semiconductor laser 4 is input to the coupling circuit 5, and by collecting light using this lens system, the signal becomes an injection light signal injected into the 2<sup>nd</sup> semiconductor laser 2. Moreover, an optical isolator is provided in the coupling circuit 5, and the output light from the 1<sup>st</sup> semiconductor laser passes this light isolator with a low

loss of 1dB or less, and because the reflected light from the 2<sup>nd</sup> semiconductor laser 6 is received with degradation of 25dB or more, the reflected light is difficult to return to the 1<sup>st</sup> semiconductor laser 4. The 2<sup>nd</sup> semiconductor laser 6 has a structure identical to the 1<sup>st</sup> semiconductor laser 6, and is utilized with almost the same characteristics. The threshold current is 30mA at 25°C and the oscillating wavelength is approximately 1.56 $\mu$ m.

The other of the two signals of the branching circuit 2 is introduced to the 2<sup>nd</sup> driving circuit 7, and along with the pulse peak value being exchanged for a signal of 60mA, the signal is applied to the 2<sup>nd</sup> semiconductor laser 6 by superimposing on the direct current bias current of slightly lower value (29.5mA) than the threshold current of the 2<sup>nd</sup> semiconductor laser.

When the 2<sup>nd</sup> semiconductor laser 6 has a light injection signal which is not injected from the 1<sup>st</sup> semiconductor laser 1, the output light pulse peak value is 5mW, the pulse on-off ratio is 15dB, with the light spectrum oscillating in a multi vertical mode (the vertical mod gap is 4Å and 1/2 the total width of the spectrum winding 30 Å).

The excitation signal of the 2<sup>nd</sup> semiconductor laser 6 is synchronized with the light injection signal, and the phase of the output signal of the 2<sup>nd</sup> driving circuit 7 is determined. Fig. 2(d) shows the waveform of this excitation signal. In addition, the single spectrum when the encoding of the injection light signal is "1" matches one of the multi vertical modes in the spectrum of the 2<sup>nd</sup>

semiconductor laser 6, and the temperature of the 1<sup>st</sup> semiconductor laser 4 is controlled.

Under these kinds of conditions, when the injected light signal is injected to the 2<sup>nd</sup> semiconductor laser 6, the oscillating light spectrum of the 2<sup>nd</sup> semiconductor laser 6 becomes a single spectrum having matched to the single spectrum which is the oscillating light spectrum of the injected light signal. In addition, when the encoding of the output pulse of the 2<sup>nd</sup> semiconductor laser 6 is "0", because the encoding of the injection light signal is also "0", the injected light level is low, and it is possible to suppress the generation of small noise. Moreover, by the above described kind of light injection, the peak value of the output light pulse of the 2<sup>nd</sup> semiconductor becomes approximately 5.3W. Fig. 2(e) shows the output light pulse of the 2<sup>nd</sup> semiconductor laser 6 at this time.

Moreover, in the above described embodiment, the wavelength for the 1<sup>st</sup> and 2<sup>nd</sup> semiconductor lasers 4, 6 used is approximately 1.56 $\mu$ m and is a InGaAsP semiconductor laser of embedded hetero structure, and the wavelength, materials, and structure may be the same. For example, it is easy to obtain a light spectrum of high monochromaticity also with a small light output, and high output light may be easily divided for the 2<sup>nd</sup> semiconductor laser to which injected light was injected.

In addition, the excitation signal of the 2<sup>nd</sup> semiconductor laser to which injected light is injected can be selected from only the

period of 10PS-several 100PS compared to the injected light

/294

signal. According to this type of configuration, because the injected light signal is injected directly before the oscillation of the 2<sup>nd</sup> semiconductor laser, a single spectrum injected light results and the 2<sup>nd</sup> semiconductor laser can easily oscillate at a single spectrum, and in addition, according to the injection light signal, the equilibrium oscillation of the 2<sup>nd</sup> laser semiconductor is easy to maintain.

Moreover, the oscillation wavelength of the 2<sup>nd</sup> semiconductor laser, when the output light of the 1<sup>st</sup> semiconductor laser which is injected light to the 2<sup>nd</sup> semiconductor laser is injected, may be matched to a degree which the oscillation wavelength of the 2<sup>nd</sup> semiconductor laser is drawn from the wavelength of the injected light. That is, because the maximum gap amount for possible wavelengths for which the oscillation wavelength of the 2<sup>nd</sup> semiconductor laser matches by drawing from the oscillation wavelength of the 1<sup>st</sup> wavelength is at the 0.1-1Å level, the oscillation wavelength of the 1<sup>st</sup> and 2<sup>nd</sup> semiconductor lasers may be matched in this range.

In addition, in the 2<sup>nd</sup> semiconductor laser 6 and the 2<sup>nd</sup> driving circuit 7 are established automatic control circuits for preventing changes of (illegible) or age for the threshold current of the 2<sup>nd</sup> semiconductor circuit 7, and the output power of the 2<sup>nd</sup> semiconductor laser 6 may not be affected by temperature, with the circuit controller controlling the direct current bias current so as to make

the output light power constant, and may also control the direct current bias current.

According to this invention, a light injector transmitter may be obtained that controls noise from an injection semiconductor laser by injected light as explained previously.

#### 4. Brief Explanation of the Drawings

Fig. 1 is a block diagram showing the structure of one embodiment of this invention, and Fig.2 is a signal waveform diagram of each part for explaining the embodiment.

1- electrical signal input terminal, 2- branching circuit, 3, 7- driving circuits, 4, 6-semiconductor lasers, 5- coupling circuit.

Figure 1

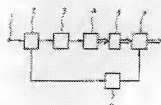


Figure 2

